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STUDDED TIRE WEAR IN MONTANA

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
Studded Tire Wear In Montana	December 1974
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s)	7923
Edward C. Miller	
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Montana Department of Highways Materials and Research Bureau Helena, Montana 59601	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Final
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

In the autumn of 1971, the Department of Highways began an evaluation of the effect of studded tire usage on Montana pavement surfaces. During winters of 1972 and 1973, approximately forty-five percent of Montana drivers used studded tires. Pavement surfaces are ice or snow packed during the worst winter months approximately 30% of the time. On high type bituminous concrete pavement the average wear for a two year period was less than 1/16 inches or a ½ inch of wear in approximately 20 years. Because of relatively light traffic volumes studded tire wear does not significantly increase costs of maintaining Montana's pavement surfaces.

17. Key Words	18. Distribution Statement
Studded Tires, pavement wear	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8–72) Reproduction of completed page authorized

STUDDED TIRE WEAR

IN MONTANA

FINAL REPORT

By

Edward C. Miller, P.E.

Supervisor Research Section

Research Study No. 7923

Conducted by

MONTANA DEPARTMENT OF HIGHWAYS

MATERIALS & RESEARCH BUREAU

In cooperation with

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

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ACKNOWLEDGEMENTS

The Montana Department of Highways wishes to acknowledge the work of Dr. J. L. Knox, Montana State University Electronic Research Laboratory, who assisted in design and fabrication of wear measuring equipment which made this study possible.

Background and Legislation

Studded tires for automobiles were developed in the Scandinavian countries in about 1961 and were marketed in the United States as early as 1963. Their use was generally outlawed by state statutes. In Montana, Section 32 - 1129 Restrictions as to Tire Equipment, states under (b), "No tire on a vehicle moved on a highway shall have on its periphery any block, stud, flange ... other than rubber which projects beyond the tread of the traction surface of the tire, except that it shall be permissible to use tire chains of reasonable proportions upon any vehicle when required for safety because of snow, ice or ...". In the 1971 Legislative Assembly this law was amended to allow the use of metal studs between the dates of October 1, to May 31.

Because of visual signs of wear to pavement surfaces, caused apparently by motorist use of studded snow tires, the State Highway Engineer in April of 1971 asked that research be conducted to establish whether or not studded tires would be harmful to road and bridge surfaces throughout Montana.

By 1971, Ontario's Department of Highways had completed a study on pavement wear in the Province due to studded tires. Their research was conducted to measure safety performance of studded tires compared to snow tires and regular highway tires. As a result of these studies the Ontario Department of Highways initiated legislation which outlawed their use. Minnesota's Legislature had approved winter usage of studded snow tires in 1965 for a two year period, and again in 1967 allowed continuation of their use for an additional two years while their highway department made an in-depth evaluation of possible safety features and possible pavement damage. Eight state highway departments contributed research funds to the project and at its conclusion, the Minnesota Legislature banned the use of studded tires in Minnesota. Utah's Department of Highways also banned their use though recently the Utah Legislature reversed that decision but increased the tax on tires with studs. Other states involved in the study still allow their use although several legislative measures are being considered to ban their use.

Research Objective

The Montana Department of Highways philosophy in this study was to determine the extra costs required to maintain Montana's highways if studded tires continued to be used in cool weather months. The study made no attempt to analyze any change relative to the increased or decreased safety experienced by a user of studded tires. Nor was our approach to determine what winter conditions had to exist before studded tires were superior to other traction aids. It was our belief that Montana motorists could be buying studded tires primarily for their increased traction on mountain passes and steep city streets rather than for increased safety relative to stopping distance. This belief was given credence by the fact that of 17,688 vehicles examined in the state over two winter seasons, less than 10 had studded tires on the front wheels where the brakes are more effective.

Research Approach

With the Minnesota report defining the parameters which affect pavement wear, Montana's study was designed to measure the local influence on these parameters as follows:

1. Wear - Three sites were chosen to measure actual wear on pavement surfaces caused by studded tires. The first site was on Montana Avenue in Helena, an urban four-lane street. It has an asphalt concrete pavement which had been recently reconstructed and opened to traffic nine (9) months before the study. The second site was located between Laurel and Billings on a rural four-lane Interstate highway with asphalt concrete surface and carrying the highest volume of rural traffic in the state. The third site was west of Missoula, a rural four-lane Interstate highway with a Portland cement surface. All sites, were constructed from hard, durable, Montana aggregates found locally in the vicinity of each highway project.

2. Snow Packed Roadways - For a three year period, daily road condition reports were analyzed to determine the percentage of time

Montana's highways were either bare, intermittently snow packed, or icy. When highways are snow packed or icy, studded tires do not wear the surface. With this information the percentage of time studded tires were wearing highway surfaces was determined.

3. Percent of Vehicles Using Studded Tires - Minnesota found that wear was directly proportional to the number of studded tire passes over the pavement surface. At each site selected, the Montana Department of Highways had good data on traffic volumes and percent of truck traffic. Early investigation proved that studded tires on trucks above the 3/4 ton capacity were virtually non-existent. Therefore, the number of studded tire passes can be found by determining the ADT (average daily traffic) of passenger cars and light trucks only, and reducing this traffic to the percentage that are using studded tires.

4. Tolerable Wear Levels - Even though the wear rate can be determined by laboratory and field measurements, the tolerable wear depth before unsafe conditions would require resurfacing the pavement remained to be defined. Ruts too deeply cut would accumulate water in the wheel paths, thus reducing visibility with the spray created behind trucks or in lines of cars. Also, accumulated water contributes to the hydroplaning of moving vehicles, and in cold weather, freezes into icy ribbons making the road difficult and dangerous to drive. Wisconsin found that a rut depth of ½ inch or more is sufficient to cause a hazardous condition, therefore ½ inch was used for the criteria of maximum wear before maintenance was mandatory.

Profilometer Equipment

Not long after the studded tire study was proposed and a preliminary literature search was completed, the problem of accurately measuring studded tire wear became a major challenge. From preliminary calculations using Minnesota's wear factors and Montana's traffic, the wear over a year period could be less than 1/32 inch. The pavement texture itself would easily equal or exceed that magnitude. How, then, could one be sure that studded tires

caused a certain change observed or measured? The results would be questionable, unless the exact profile across the pavement surface could be scribed repeatedly and with accuracy within a tolerance of ± 0.01 inches.

After additional research on various photographic and physical measuring systems used by Ontario, Minnesota and Washington State University, a decision was made to sub-contract to the Montana State University Electrical Engineering Department, the work of designing and constructing a measuring device or profilometer which would meet or exceed our requirements.

A picture of the profilometer proposed and built is illustrated in Figure 1, (Page 5). The profilometer consists of a 1 3/4" x 3½" x 6'-6" aluminum beam which straddles the wheel paths and rigidly support a moving stylus. The spindles at each end were designed with threads to fit the anchor pins set beneath the pavement surface. Figure 2, (Page 7), is a close-up of the stylus, vertical potentiometer and a pulley wrapped with one loop of fine wire. As the profilometer head is pulled horizontally along the beam the distance traveled by the stylus is determined by the rotation of the pulley wheel. When the beam is mounted on the anchor pins the stylus wheel is in contact with the pavement surface.

Figure 3, (Page 9), shows the design features of the spindles. The spindle has a female end with threads to fit the anchor pins and a shoulder formed a little below half its length. The shoulder gives a solid base for the beam to set upon. Vertical holes in the beam 3 inches from the ends were made to fit the spindle shank. The washers and wing nuts held the beam tightly against the spindle shoulder and rigidly in place. Figure 4, (Page 11), shows the beam mounted on the spindle.

The "X", "Y" coordinate plotter, which was used to convert the electrical impulses from the potentiometers to the plotter pen, draws a graphical representation of the pavement surface. The plotter is shown in Figure 5, (Page 13), and a typical plot is illustrated in Figure 6, (Page 13).

With Montana State University designing a measuring system capable of plotting pavement variations in the order of ± 0.010 inches, the necessity of

Figure 1. The picture shows details of the profilometer and end spindles. The profilometer is used to plot the surface profile transverse to a wheel path.

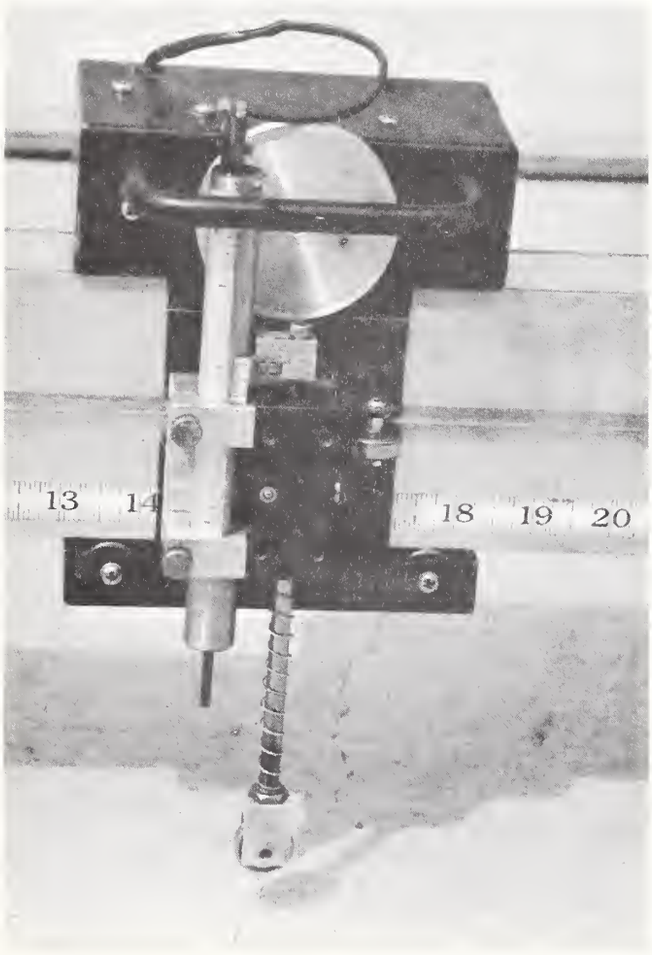

Figure 2. Close up view of the profilometer head showing beam track, wheel stylus, vertical potentiometer and horizontal pulley with wire.

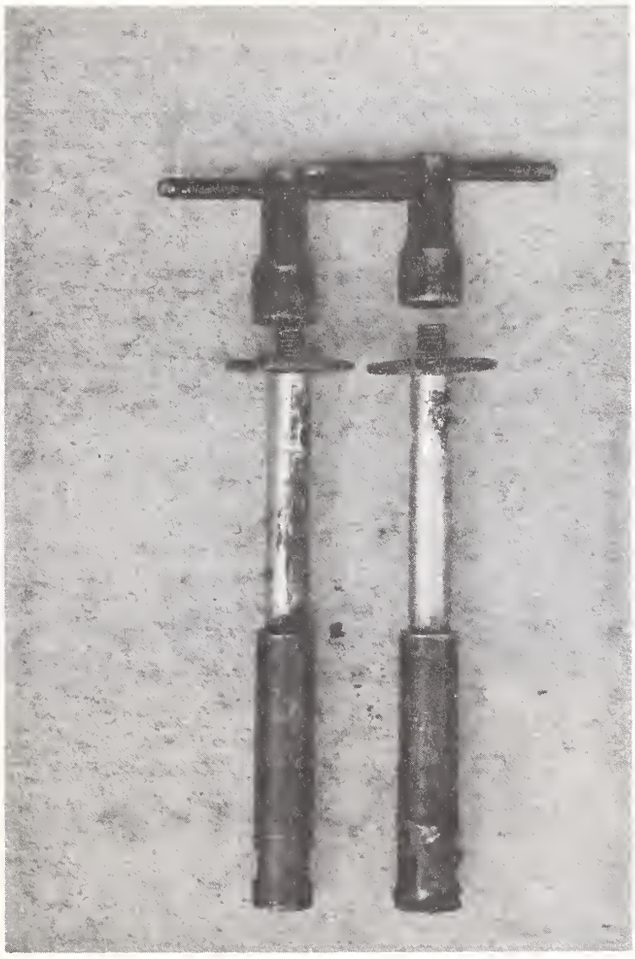

Figure 3. Close up view of spindles with wing nuts and washers. The spindles held anchor pins in exact position until the liquid sulphur hardened in the holes. A pin hole below the washer fit a horizontal alignment hole drilled through the template cylinder and spacer sleeve. The spindles and anchors were painted red and black to match mark.

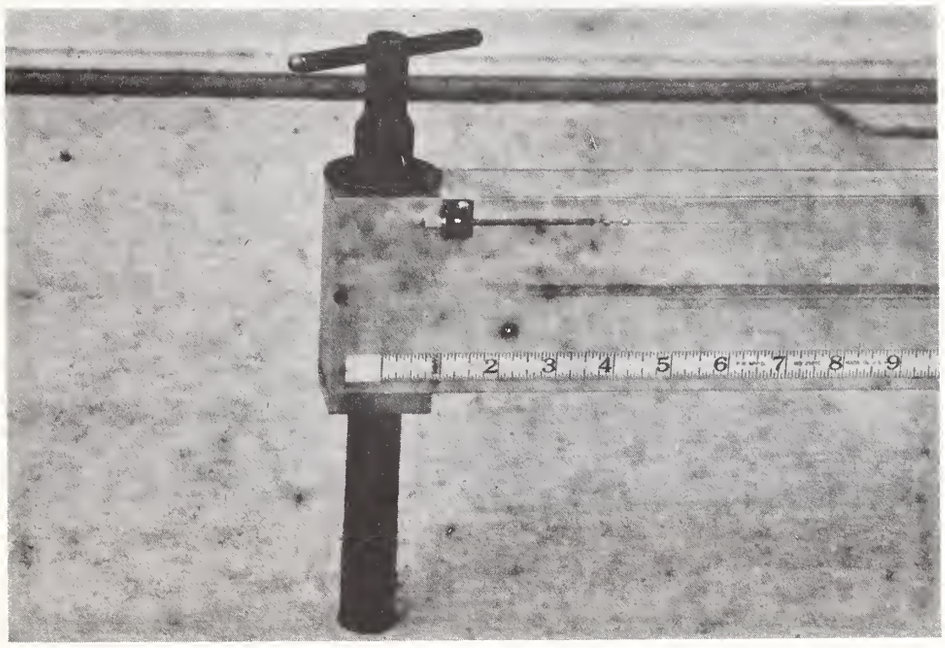

Figure 4. Profilometer mounted on spindle. The female end of the spindle is threaded to fit the anchor pins.

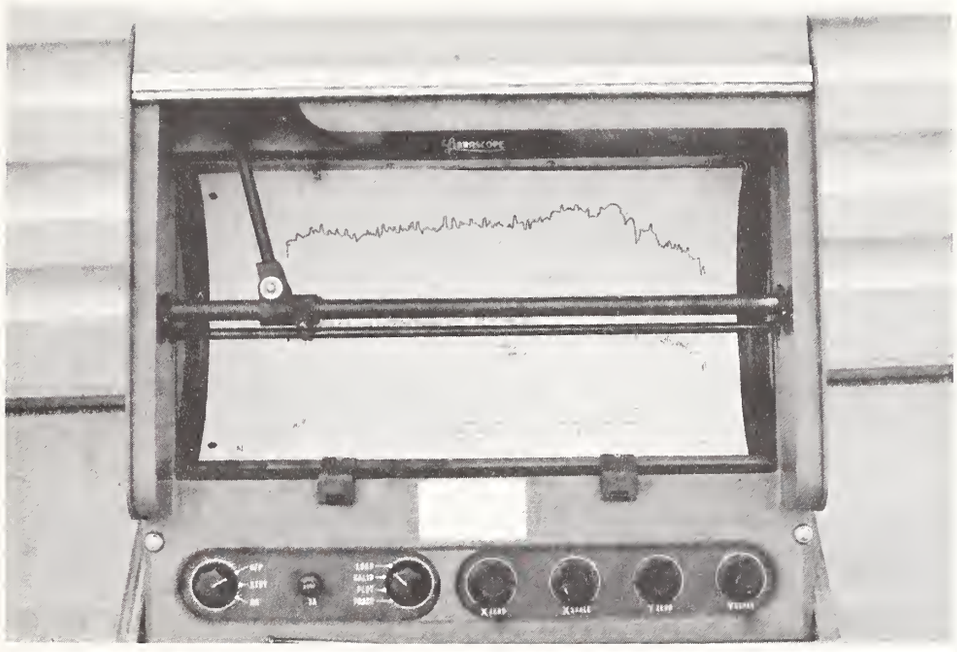

Figure 5. This view of the "X", "Y", plotter shows the plotting mechanism, the knobs to control scale and to change the origin as required to get the total plot on the paper.

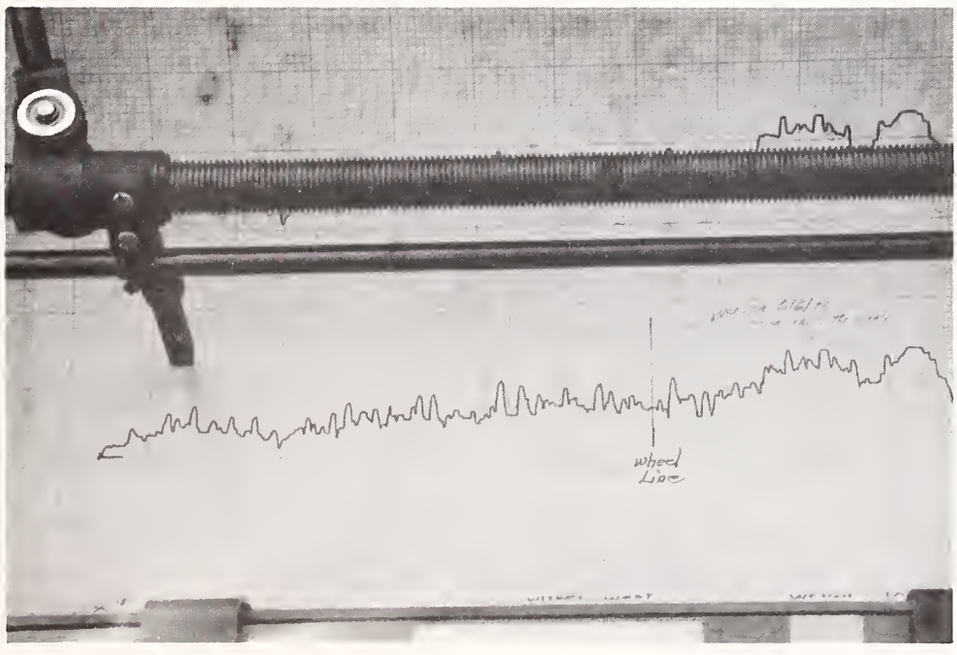

Figure 6. A close up view of a typical surface plot across the wheel path. A large square scales 6 inches horizontal and 0.10 inches vertical dimension.

setting anchor points accurately and solidly was of major importance. To accomplish the objective, reference pins were made from threaded ½ inch diameter rods set 1 inch below the pavement surface on 6'-0" centers. A steel template shown in Figure 7, (Page 15), was used to position the holes which were jack-hammered to the proper depth and filled with hot sulphur to the bottom of the anchor pin shoulder nut. Sulphur was selected for the cementing compound because it has a quick set allowing traffic back on the lane within a short time period. Also, sulphur has a strong bond, it is relatively inexpensive and is readily available.

Figure 7, also shows the sulphur pot, ladle, anchor hole covers with brass caps and ½ inch diameter threaded rods with a welded nut for the spindle stop. In Figure 8, note the pin holes in the vertical template cylinder. A steel aligning pin driven through the cylinder, a cylinder spacer sleeve and the holes in the spindle shank below the washers (Figure 3), held the rods in exact vertical and horizontal position until the liquid sulphur was ladled down the half circle trough into the hole and solidified. The top of each rod set one (1) inch below the road surface after the template and spindle were removed.

Before rods were set in sulphur, a solid stop had to be formed so that the spindle could be tightened repetitively to an exact elevation. A hex nut welded to the rod at the proper location formed the stop for the spindle and also acted as the marker for filling the anchor holes with liquid sulphur. Approximately 1½ inches of threaded pin protruded above the sulphur making a solid anchor for the spindles and thus a solid base for each end of the aluminum beam.

The two spindles were painted, one red and one black, and each pair of reference pins were painted accordingly so the same spindle would be used with the same reference pin. In this way close tolerance could be assured between successive setups.

To prevent dirt and moisture accumulation in the anchor hole, regular 3 inch diameter pipe cleanout plugs fitted with brass caps were set over the pins and level with the pavement surface. They were held in place with sulphur.

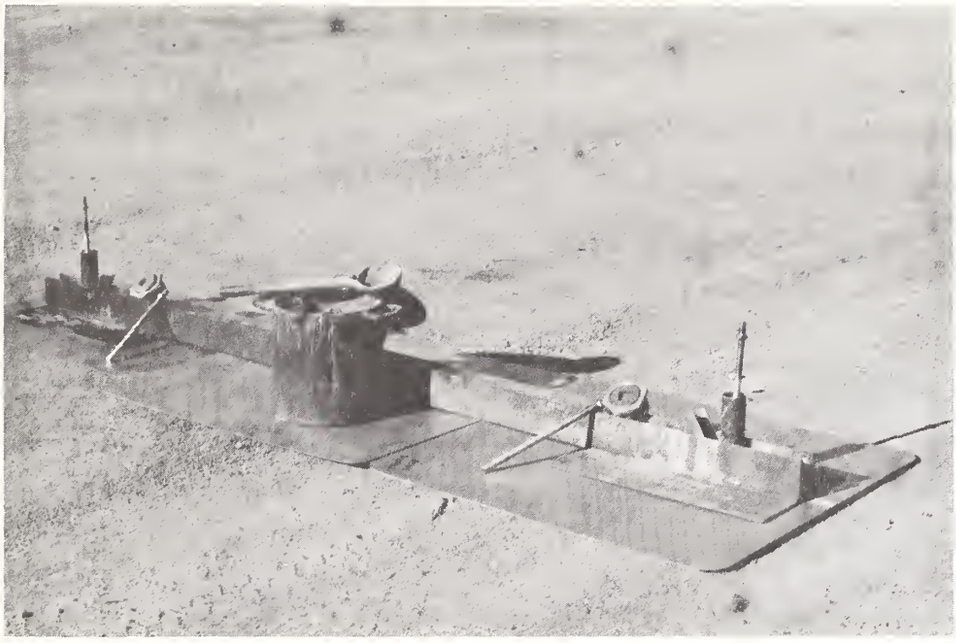

Figure 7. Template used to set anchor pins 1" below the pavement. Picture taken of template set on traffic signs and showing vertical alignment cylinders, anchor pins with welded shoulder nuts, anchor hole covers with brass caps, sulphur pots and ladle.

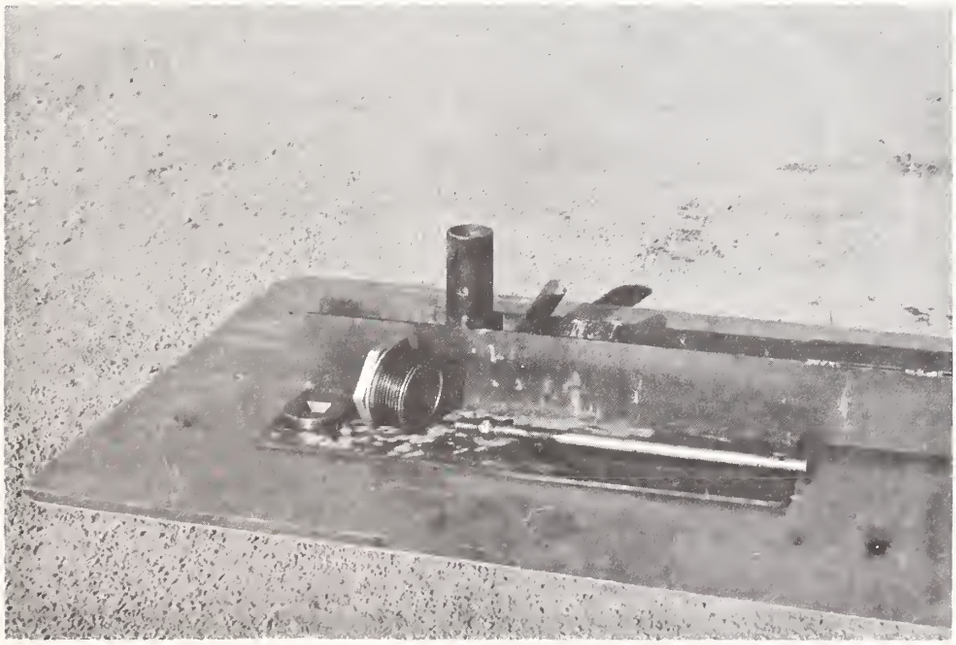

Figure 8. Close up view of template with vertical cylinder, horizontal alignment hole, pavement cover with brass cap. anchor pins and half circle chute for molten sulphur.

Pavement Profiles

The proper vertical and horizontal plotter scale was checked after each set up to assure excellent repeatability. In the vertical direction the plot registered ten times greater than the stylus movement, while in the horizontal direction the plot registered at 1/6 the stylus movement. Thus the plotter movements were distorted with the vertical being sixty times the horizontal; a scale of one inch equals 10 inches vertically and one inch equals 0.1667 inch horizontally was used for all profiles. A typical plot is shown in Figure 6, (Page 13). Each profile was repeated to be sure the plotter was working properly and so both plots could be used to calculate wear should more than one be necessary.

The initial road surface profiles were taken after the bearing pins were set in sulphur and all covers were in place. The three sites were completed by February 1972 and the initial profiles taken. At various intervals throughout a twenty-two month period, five other profiles were taken.

Missoula - Frenchtown Site

At the Missoula-Frenchtown site the initial measurement was on a new concrete surface on a rural section of Interstate 90. The initial profile was taken before the section was opened to traffic so maximum concrete wear could be expected the first few months as the rough pinacles of the surface were worn or knocked off. After 21 months of traffic, the maximum change over the entire profile was 1/24 inch and the average change was about 1/50 inch. Figure 9, (Page 17), shows the combination of six plots across the wheel paths of the outside lane. At the measured rate of wear, the pavement surface would last twenty-five years before a rut depth of ½ inch developed. The wear rate could be even less than stated above because the accuracy of the plotter is no better than $\pm$ 0.010 inches. All six plots for more than ninety percent of their length stayed within that range. Therefore, the measured differences could have been the chance variations of the plotting equipment. The frequent crossing of plot lines verifies the assumption that the total wear as yet cannot be accurately measured with our instrument and that a longer period of exposure will be necessary. From this analysis one

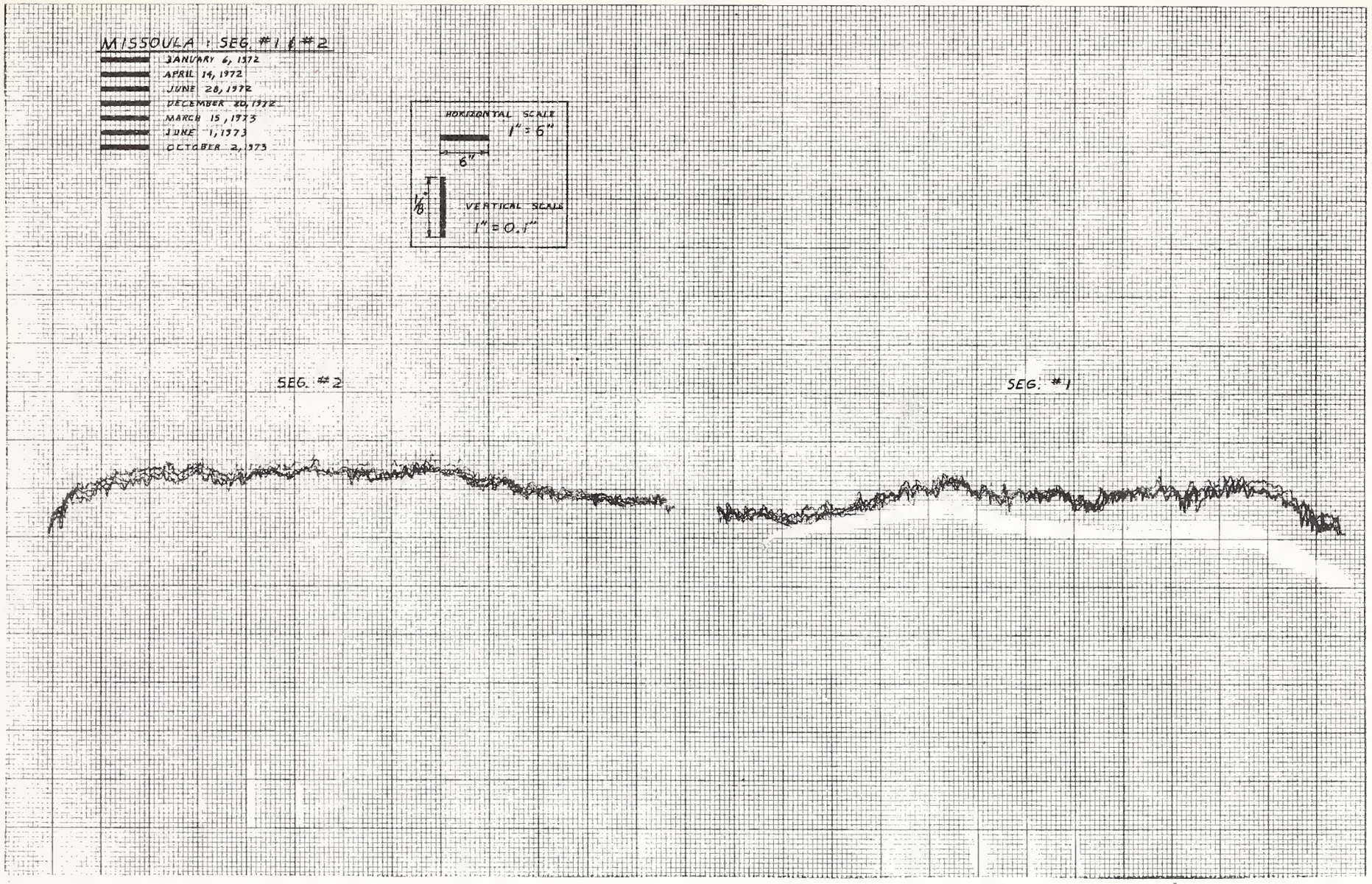

Figure 9. A composite of seven plots taken at the Missouls-Frenchtown site. The last plot was made 21 months after the initial plot. Notice the excellent repeatability of plots of this concrete surface.

could conclude that a half inch of total wear will not occur until the year 2000 or later.

From observation of the concrete pavement no surface wear is visible on the inside traffic lane and only a change in color and slight textural change is discernible in the outside or heavier traveled lane.

Billings - Laurel Site

At the Billings-Laurel site on a rural section of Interstate 90, studded tire wear was measured at three different locations. This site was particularly chosen because of three important factors. First, a permanent traffic counter is located within the section so an accurate count of traffic was assured and the exposure of pavement surfaces to studded tires could be accurately predicted. Second, this section of Interstate highway carries the highest rural traffic volume and consequently should wear faster than other sections. Third, a weigh station is located within the section which is open 160 hours per week or 95% of the time. Therefore, heavy truck traffic is diverted off the traffic lanes onto the weigh station approach ramps. With heavily loaded trucks diverted through the weigh station, a cross section was selected which would not be subjected to the load deformation normal to all other sections of the roadway

Three test areas with unique factors for studded tire wear and load deformation were established with in the test site. The first area extended across both lanes of the east bound interstate about one mile ahead of the entrance to the weigh station ramp. This area carried all eastbound traffic. The second area was across both east bound traffic lanes but beyond the entrance to the weigh station ramp. This area would have minimal usage by heavy truck traffic which is diverted into the weigh station. The third area was across the weigh station ramp. This area would have minimal usage by heavy truck traffic which is diverted into the weigh station. The third area was across the weigh station ramp, tangent to the direction of travel, and where most drivers were not applying brakes. This area carries the majority of heavy truck traffic. The researcher anticipated an opportunity to physically measure studded tire wear (area # 2), heavy load deformation (area # 3) and the combination of both (area # 1) in an asphalt concrete pavement surface.

The cross sectional area between two consecutive profiles was computed for a wheel path twenty inches wide. These areas represented the wear and/or deformation which developed between the profile measurements of the first and second plot, the first and third plot, first and fourth plot, etc. In this way it was thought one could accurately determine wear with time.

The profiles taken did not support the results anticipated. Successive plots did not always register below the previous plot in the wheel paths. In one case, ground frost changed the reference pins differentially and caused successive crossing of the plot lines. Weigh station ramps evidently has less load resistance than the Interstate lanes, and deformation due to heavy loads was greater on the ramp than both heavy load deformation and studded tire wear on the main Interstate lanes. Some of this difference could be due to the division of truck traffic between the two main line Interstate lanes and concentration of truck traffic on the single weigh station approach ramp. In order to better analyze the results, all six plots of both wheel paths in a traffic lane were placed together. From these plots, the following conclusions can be drawn:

1. Because there exists no pattern to the position any plot holds in a graph of all six plots, there is no way to measure progressive wear, deformation or combination of the two at the Billings sites.

2. Area 2 had a more scattered pattern of plots than area 1 even though area 1 was subjected to the heavy truck traffic. Thus the freeze thaw cycles or other climatic conditions may have a greater effect on surface movement when the lanes do not carry heavy loads. In any case the experiment failed to differentiate between the effects of wear and deformation.

3. Areas 1 and 2 have four wheel paths to be studied for a total of eight places where profiles were taken on the main line. Of the eight wheel paths plotted at the two areas, five retained all six profiles within a $\pm$ 1/32 inch tolerance while two other wheel paths retained all six plots within a $\pm$ 1/16 inch tolerance. Thus the wear and deformation together was less than 1/8 inches and averages

less than 1/16 inches. Because previous research has held that studded tire wear is proportional to the number of studded tires passing over a pavement surface, the five wheel paths with all plots falling within $\pm$ 1/32 inches would indicate that the maximum wear and deformation could be no more than 1/16 inches. Again, the random position of any one plot to all plots within the section shows that time was not a factor in these relationships. However, time is a factor in wear, therefore, it can be concluded that factors greater than and other than wear are affecting the results. Furthermore, because the instrumentation used to gather the information stayed within its design plotting tolerance of less than $\pm$ 1/64 inches on concrete pavements, it is reasonable to assume that the equipment was as reliable on asphalt pavement. It is therefore concluded that on the Billings-Laurel Interstate rural highway where traffic is the highest in the State of Montana and where the percent of cars and pickups using studded tires has been estimated to exceed 45% in mid-winter months, the studded tire wear is considerably less significant than other factors affecting the pavement.

4. The weigh station ramp showed a greater tendency toward deformation than the Interstate lanes as the ramp wheel lines are in troughs slightly more than ¼ inch deep. A periodic check of trucks through the weigh station indicate that none are using studded tires, therefore the total displacement is due to deformation. The relatively narrow width of the trough, Figure 10, (Page 21), indicates that nearly all trucks are positioned at the same place on the ramp. That fact along with the fact that slower truck movement on the ramp would result in longer load application and could cause deeper deformations.

5. The six ramp plots had more vertical dispersion than those on the main traffic lanes; but again, profile changes were completely random with regard to time. The plot taken on June 5, 1973, was the highest, and the plot taken on September 26, 1973, was the lowest, and all other plots were in between.

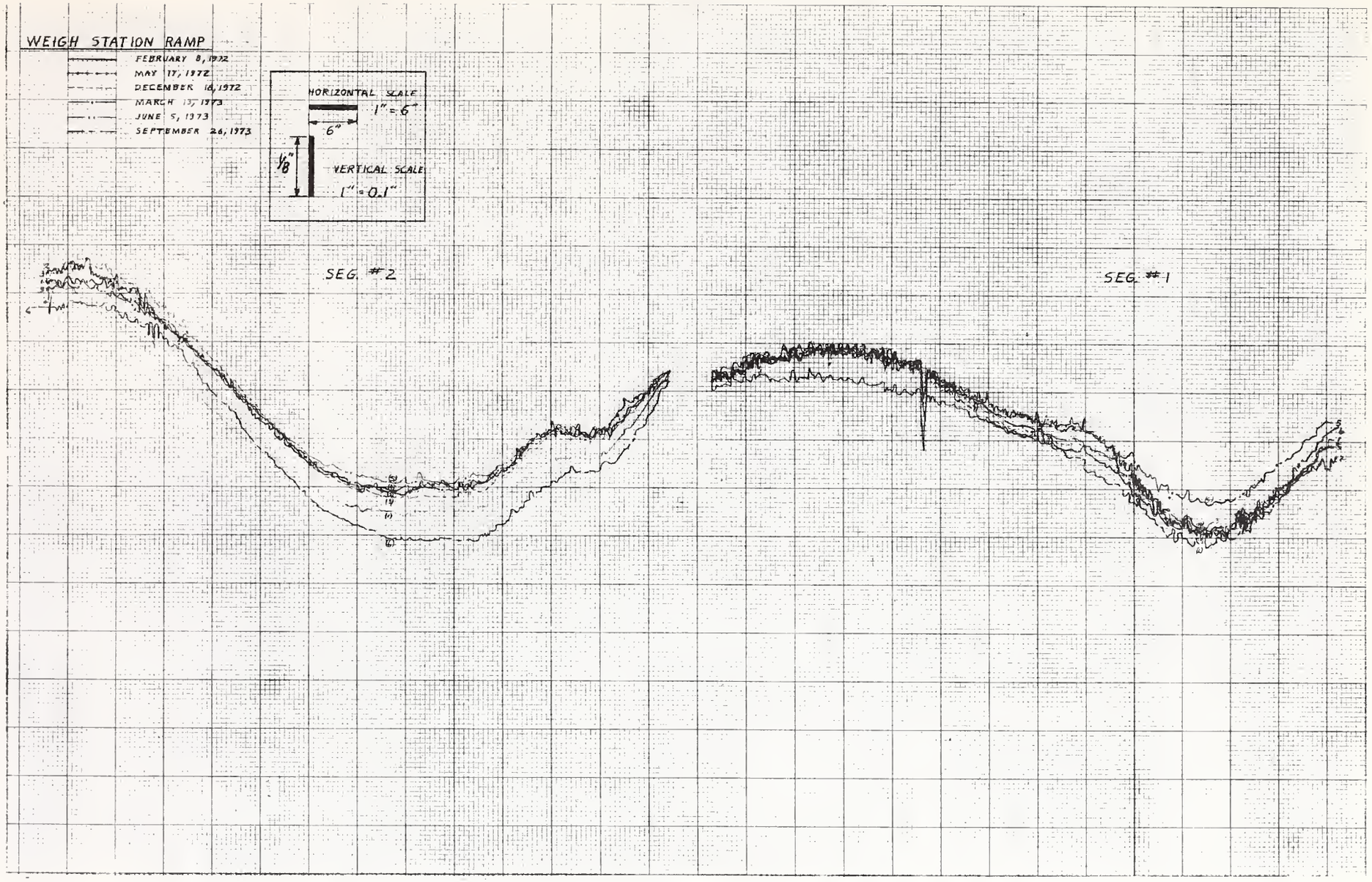

Figure 10. A compsoite of the plots taken on the exit ramp of the weigh station at Billings-Laurel site. The plot illustrates the pavement deformation due to heavy truck traffic.

Helena Urban Site

A site was chosen within the city limits of Helena on Montana Avenue to evaluate wear values on heavily traveled urban extensions of the highway system. This location was the first to be installed because of its proximity to Helena Headquarters where changes in plans or equipment could be made if required.

It was envisioned that core drilling would provide the best method of making holes for the anchor pins. The method was soon changed because of the time consumed maneuvering large equipment to core a hole in precisely predetermined locations. The water required to drill holes ran over the street causing icy conditions and wet holes required drying time before hot sulphur could be poured around the pins.

The method was changed and a jack hammer was used to penetrate and dig the hole. As a result, more sulphur was required to fill the larger non-uniform hole, but the efficiency of the operation improved until all pins for a site were set within the work day. Another problem developed with the template. After the anchor pins were set, it was found that the brass caps could not be tightened as the anchors were slightly too high. Without tight caps, water penetrated the anchor holes and froze, preventing the use of the anchor pins during cold weather. Also the ice broke the bond between covers and pavement on two anchor pins. The covers disappeared with the heavy traffic, exposing the anchors to dirt and rust. With the help of a small rethreading device, these pins were used but the profiles may be less reliable.

The plots showing the widest dispersion varied by $\pm$ 3/32 inches, and those with a narrow band varied by $\pm$ 1/16 inches. On Montana Avenue the northbound traffic lane has a $\pm$ 1/16 inch dispersion while the southbound inside lane had a very close $\pm$ 3/64 pattern in one wheel line and $\pm$ 3/32 pattern in the other.

Again the plots showed a random pattern relative to time, Figure 11,(Page 23); therefore, no wear could be determined. Other factors including

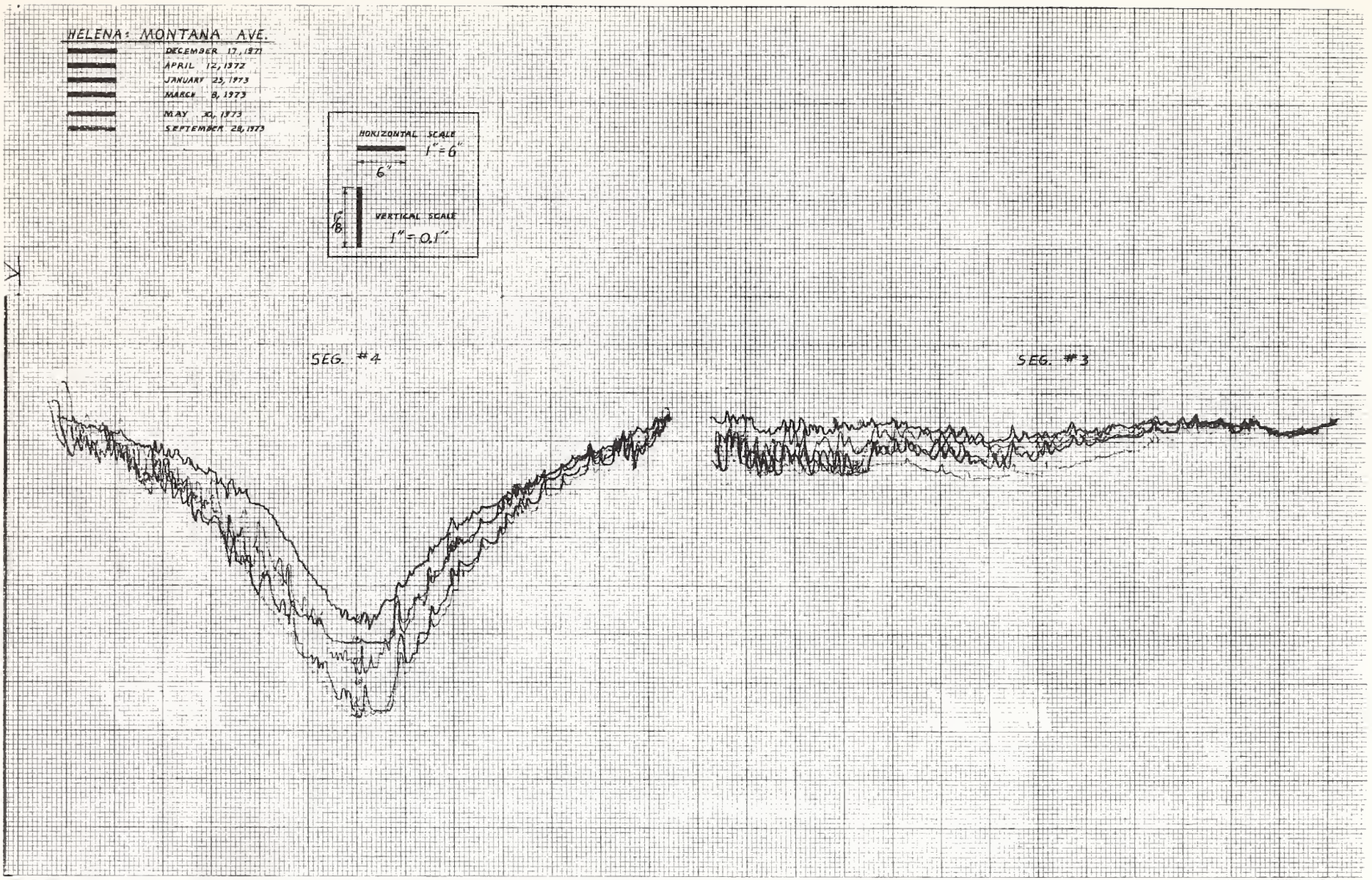

Figure 11. A composite of data demonstrating a random pattern relative to time for a Helena Urban site.

climate were effecting the results of the plots much more than wear or deformation or the combination of the two. On any future installations, it is recommended that chromium steel be used for anchor pins because threaded pins that would not rust would be more reliable.

It is possible that more information could be learned about freeze thaw conditions relative to the surface movement of asphalt pavements if more frequent plots were taken over an extended period of time. In those cases temperature and frost penetration would also need to be monitored.

Studded Tire Usage

Three methods were tried as a means of estimating studded tire usage in Montana. The first and only successful method was to count vehicles along city streets, in parking lots of shopping centers, office buildings or commercial garages. From counts in Billings, Helena and Missoula, a graph Figure 12, (Page 25), was plotted which shows that about 46% to 50% of the passenger cars and pickups or small delivery trucks use studded tires in mid-winter. The percentage decreases to about 25% in April and 4% in early June. A small percentage (1 or 2 percent) continue the use of studded tires throughout the summer months in violation of the law. This use evidently is to wear out the tires.

The second method tried was to count cars with studded tires by listening to their sounds as they passed a point along the highway. The first trial was near a truck stop along a primary highway near Helena. Two young men with good hearing were stationed about 700 feet apart within sight of each other. A vehicle was selected to begin the count and each succeeding vehicle was classified as either having or not having studded tires. After 50 vehicles had passed along the two lane highway in the westbound direction, a comparison was made between the count of the two men. Though only a difference of one was noted in the count totals, there were eleven cars classified differently by the two observers. This is a 22% error.

THIS GRAPH ILLUSTRATES THE PERCENT USAGE OF STUDDED TIRES ON CARS AND PICKUPS IN 1972 & 1973 FOR EACH MONTH STUDDED TIRES ARE LEGAL IN MONTANA

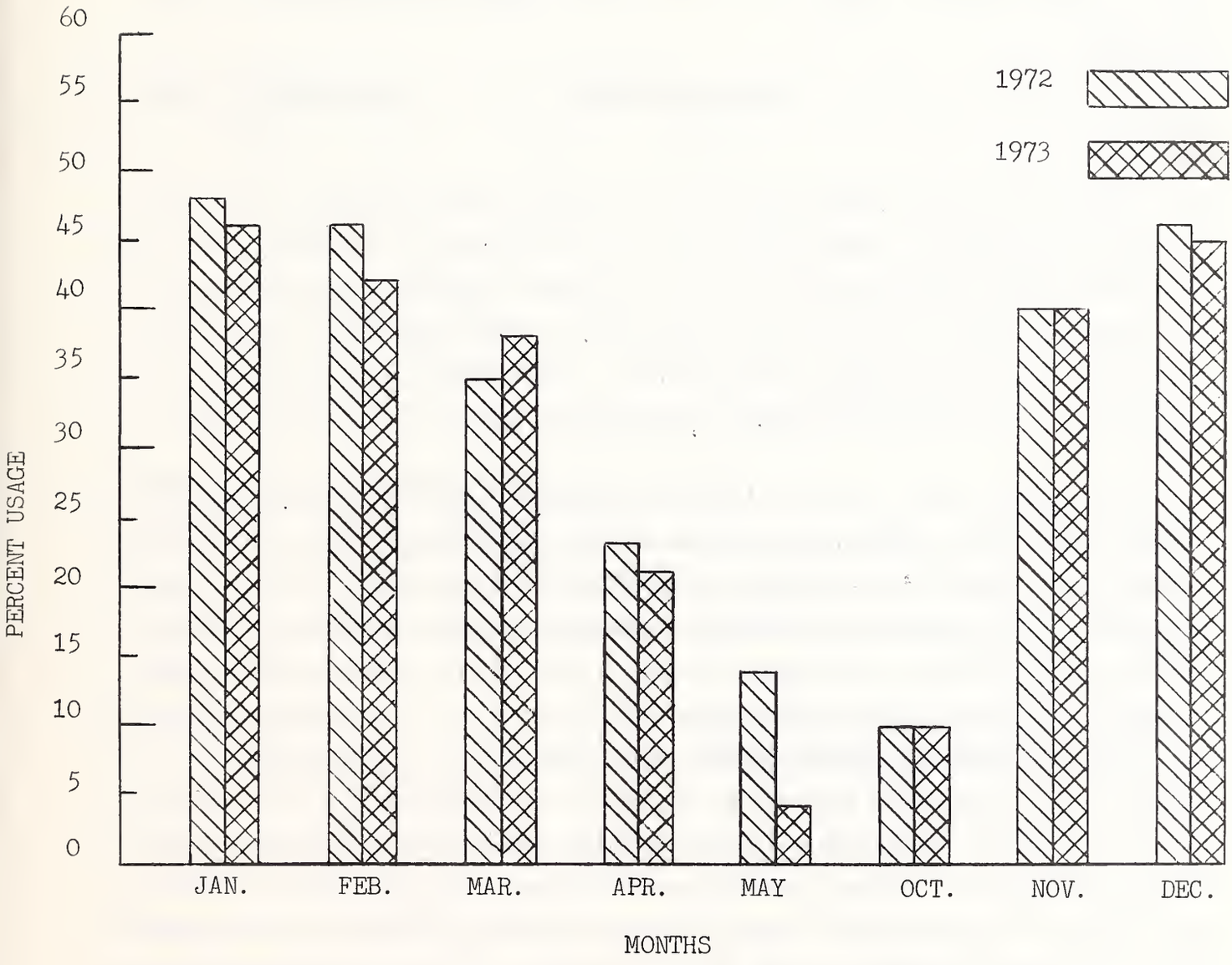

Figure 12

MAN NO.	NO. WITH STUDS	NO. WITHOUT STUDS
Man No. 1	23	27
Man No. 2	24	26

Because of truck noise around the truck stop, another site was selected on Interstate 15, a few miles north of Helena in a quiet rural area.

Thirty three vehicles passed the two observers before the following check was taken:

MAN NO.	NO. WITH STUDS	NO. WITHOUT STUDS
Man No. 1	20	13
Man No. 2	19	14

Here again the totals looked good, but in checking each vehicle classified, three were oppositely classified by the two men causing a 9% error. Most of the problem with classification by ear comes when several vehicles passed the observer within a short time interval and the studded tire sounds were obscured by noise from the other vehicles. This system is believed to be inadequate, especially on highways with heavy traffic or with multi lanes.

The third method was to count vehicles automatically as they move down the highway. The first idea conceived was to hook up a tape recorder to the expansion joint steel of the bridge decks. The click of metal on metal might be audible. This idea was immediately abandoned after a couple of trials, but the studs did give a different sound on the concrete deck. After many attempts on various bridge decks using different pick up techniques for the tape recorder and then analyzing the sound frequencies in a laboratory, Montana State University electrical engineers fully believed a true count could be taken of those vehicles using studded tires. The development costs and the manufacture of the first piece of equipment was beyond the scope of the study and certainly more expensive than counting studded tires on parked cars. It remains unknown though if rural traffic has the same percentage of cars using studded tires as was found in urban parking lots.

Percent Snowpack

In Montana the legislature has legalized the use of studded tires from Oct-

ober 1st through May 31st of each year. Our data indicates that the use of studded tires correlates well with the percent of snow packed highways. Because Montana is unable financially to keep highways free from ice and snow at all times, an analysis was made to determine the percent of interstate and primary mileage that was either icy or snow packed during months when studded tires are legal.

Daily road reports from the maintenance section foreman to maintenance headquarters in Helena were the basis for the data graphically represented in Figure 13, 14, and 15. By analyzing the daily reports from each division over a three year period, it was found that January is the worst month for snow, ice and cold and about 30% of the primary and interstate roads are snow packed or icy during the month. About 23% are snow packed or icy during December, 16% in February and 11% in November. Of course any one year can be radically different from this three year average, and one section of the state may vary from the average or from any other section.

WEAR CALCULATIONS BASED ON MINNESOTA REPORT

The Minnesota study correlated the wear rate of highway pavement surfaces with wear measured on test track surfaces at the American Oil Company's Whiting, Indiana circular test track. From this correlation, the following table was taken.

PAVEMENT GROUP		MILLIONS OF STUDDED TIRE PASSES TO 3/4 INCH WEAR DEPTH
Concrete	(Gravel)	10.1
Concrete	(Crushed Limestone)	7.4
Bituminous	(High Type)	5.1
Bituminous	(Regular Type)	3.8

Using the above table as a guide and substituting Montana's data for Minnesota's, the theoretical wear rates were calculated at the three sites where actual wear measurements were taken. Thus a correlation could be established between Minnesota's findings and the findings here in Montana.

In Montana more than thirty percent of our highway mileage is snow packed or icy during the worst winter months. It is reasoned that while pavements are

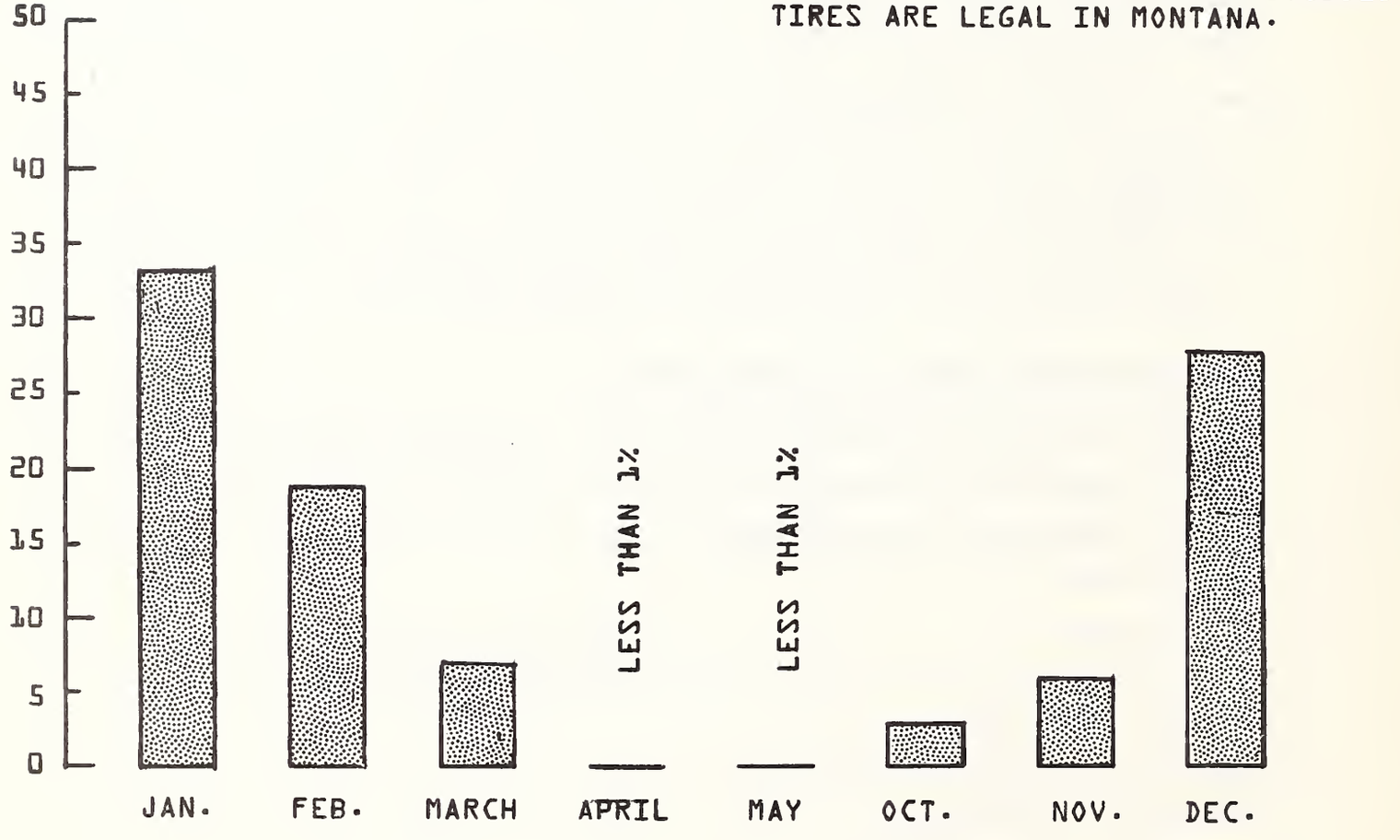
THIS GRAPH ILLUSTRATES THE PERCENT OF TOTAL INTERSTATE AND PRIMARY HIGHWAY MILEAGE FOR 1971 THAT WAS SNOWPACKED OR ICE COVERED DURING EACH MONTH STUDDED TIRES ARE LEGAL IN MONTANA.
50
45
40
35
30
25
20
15
10
5
0
LESS THAN 1%
LESS THAN 1%
JAN.
FEB.
MARCH
APRIL
MAY
OCT.
NOV.
DEC.

Figure 13

THIS GRAPH ILLUSTRATES THE PERCENT OF TOTAL INTERSTATE AND PRIMARY HIGHWAY MILEAGE FOR 1972 THAT WAS SNOWPACKED OR ICE COVERED DURING EACH MONTH STUDDED TIRES ARE LEGAL IN MONTANA.

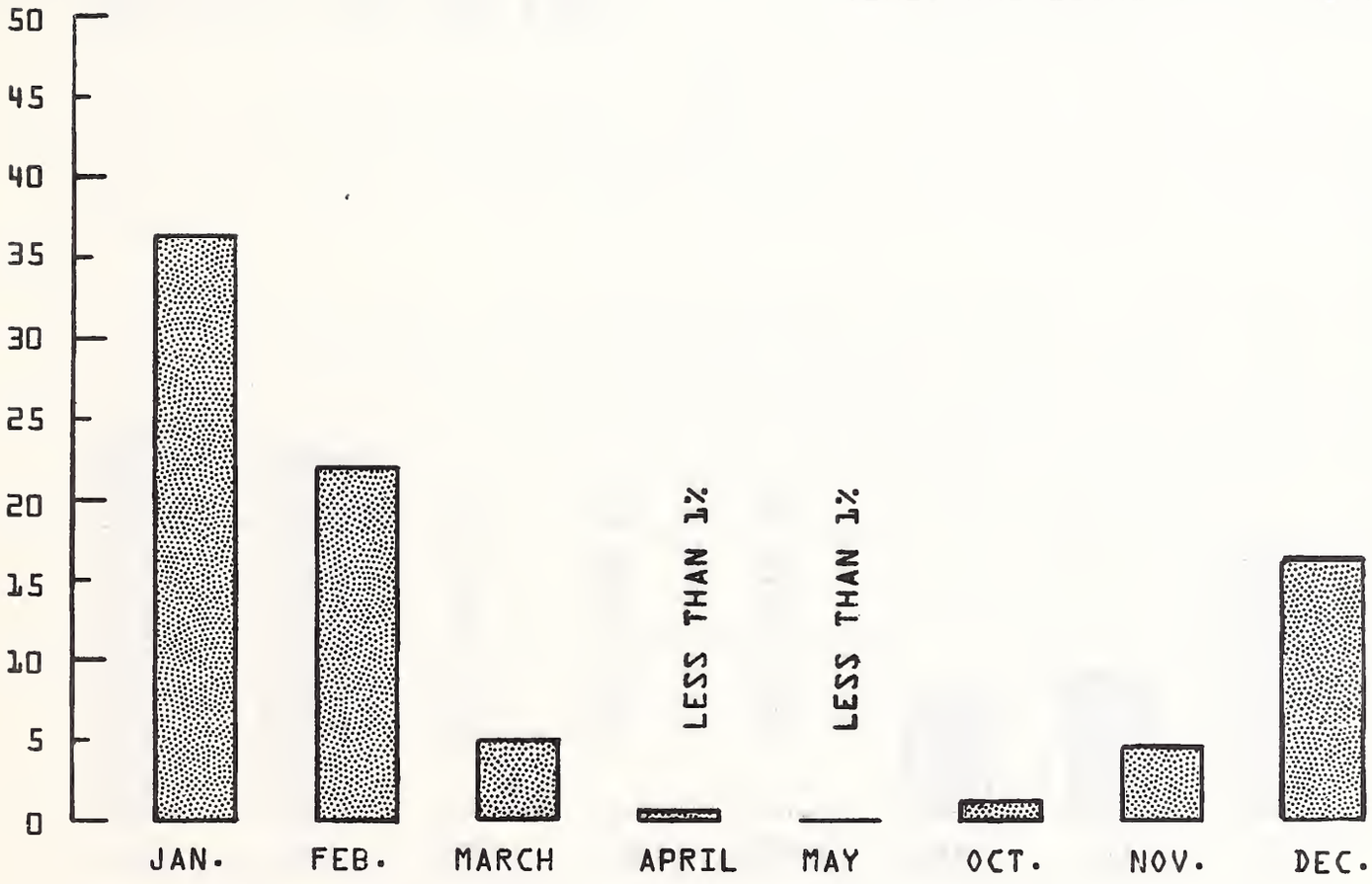

Figure 14

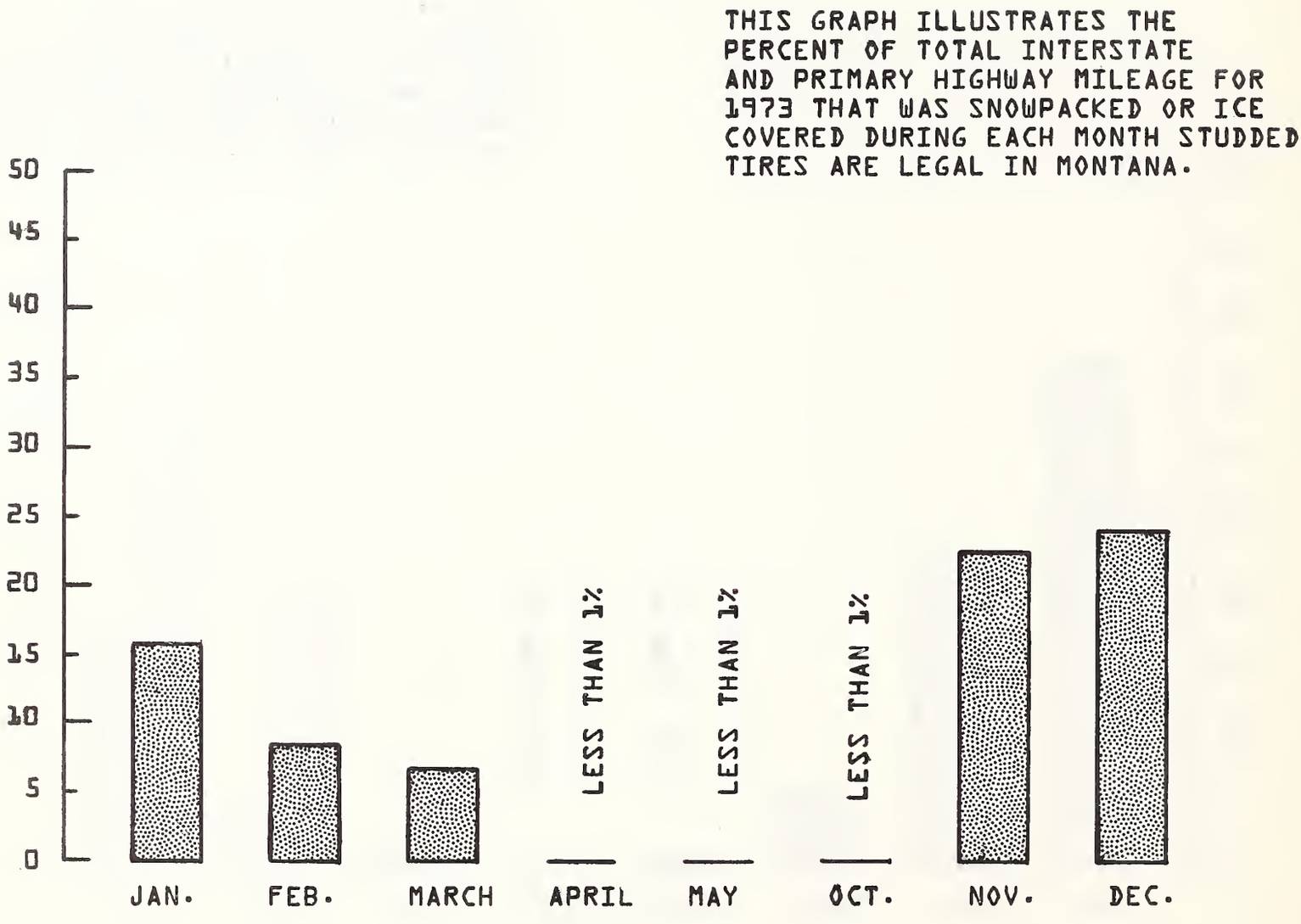
THIS GRAPH ILLUSTRATES THE PERCENT OF TOTAL INTERSTATE AND PRIMARY HIGHWAY MILEAGE FOR 1973 THAT WAS SNOWPACKED OR ICE COVERED DURING EACH MONTH STUDDED TIRES ARE LEGAL IN MONTANA.
50
45
40
35
30
25
20
15
10
5
0
LESS THAN 1%
LESS THAN 1%
LESS THAN 1%
JAN.
FEB.
MARCH
APRIL
MAY
OCT.
NOV.
DEC.

Figure 15

covered with ice and snow, little wear can be anticipated from traction aids. To correlate with the Minnesota findings, the number of studded tire passes were reduced by the percent of snow pack found during each month.

At the Missoula-Frenchtown site, wear measurements were taken on a concrete surface made of hard durable gravel. Using traffic data for this roadway section reduced to the percent of studded tires being used, the percent of bare pavement and the percent of traffic in each traffic lane, it was found that nearly 150,000 studded tires passed over the roadway surface in a two year period. At this rate of exposure,using Minnesota's formulas, the wear would be 1/128 inches per year or a half inch of wear in 64 years. In as much as our actual measurements were about 1/50 of an inch for nearly a two year period, the calculations checked favorably with our observations at the site.

At the Billings-Laurel site, wear measurements were taken on a high type bituminous pavement made of hard durable Yellowstone River gravels. Using traffic data for this section reduced by appropriate factors as explained above, it was found that for the two year study period, 334,000 studded tire passes were generated. At this exposure rate, the calculated wear using Minnesota's formula would be 3/128 inches per year or a ½ inch of wear in about 21 years. From actual measurements at the Billings site it was found that wear would average less than 1/16 inches for a two year period. At this rate, ½ inches of wear would not occur until the highway was in use for 16 years.

At the Montana Avenue site in Helena, wear measurements were taken on a bituminous pavement with hard durable aggregate. To calculate the number of studded tire passes, the same criteria was used as for the other two sites. This urban street carries the third highest traffic volume of any section in the state. For the two year study period, 623,000 studded tire passes were generated. This would yield a calculated wear of 3/64 inches per year or ½ inch of wear in about 10 years.

The higher traffic volume on Montana Avenue does have more effect on the

noticeable wear of the pavement. In the wheel paths the aggregate particles can be seen and individual pieces are distinguishable while outside these paths, the pavement texture remains without pattern and of uniform asphalt color.

EXTRA MAINTENANCE COSTS FOR STUDDED TIRES

Studded tires do accelerate the wear of both asphalt and concrete pavement surfaces. Likewise, traffic paint and other pavement marking materials are damaged by motorists using studded tires. However, in Montana severe weather conditions also damage pavement structures and surfaces such that frequent repairs are necessary. If, due to severe pavement cracking, the cracks are filled and the surface is overlayed, then any wear caused by studded tires is also repaired and the cost of material required over and above that used to rejuvenate the road surface would be negligible.

The cost required to permit studded tires on Montana roads is assumed to be the extra costs over and above required maintenance by other causes. Our design criteria is based on the assumption that bituminous pavements will be overlayed with a 3 inch plant mix surface every thirteen years. Seal coats with 3/8 inch maximum size chip are planned for between the overlays.

Thus the surface of flexible pavements call for some type of resurfacing once every 6½ years. In practice, the resurfacing of miles of roadway is deferred for many years because the demand for highway dollars for improvements exceed the income and preventive maintenance is deferred. In these cases studded tire wear may become noticeable, but except for a few miles close to our larger populated cities, the wear should not exceed ½ inch. It was found that in the Billings-Laurel section studded tire wear would require some kind of resurfacing of the asphalt pavement about once in twenty years. This period far exceeds the design resurfacing interval and therefore, the pavements would more than likely have received a resurfacing treatment to keep the road surface in good operational condition.

Pavement marking paints are applied to centerline stripes on main highways once a year or more depending upon weather problems. This study did not

determine if the stripes disappeared faster during winter months because of studded tire wear. It can be assumed that some of the stripe is diminished by studded tires but the effect this might have on safety or driver convenience is not within the scope of this study.

The repair of bridge decks could be the most costly maintenance item due to the use of studded tires. Using Minnesota's wear rates for Portland cement concrete and Billings-Laurel studded tire traffic, a half inch of wear would occur after 32 years of service. The Washington State University study finds that many factors effect the wear rate of a material. The type of studs used, the length of protrusion beyond the tire tread, the strength of concrete, percent of asphalt or cement, hardness of aggregate, etc. The Washington State University Study found wear rate per million studded tire applications to be considerably less than that of Minnesota. If WSU rates are used, then bridge decks would last over 60 years. These observations are based on present traffic volumes and the present percentage of vehicles using studded tires. If studded tire usage jumps significantly in the next few years, the projected costs due to studded tire wear will increase accordingly.

CONCLUSION

From extensive studies by Ontario, Minnesota and Washington State University and many collaborate studies, it has been found that studded tires damage highway pavement surface. Measurements of the wear rates to determine the extent of damage vary depending upon the ability of the researcher to control many factors affecting this rate and the methods used to measure small incremental quantities. On flexible pavements this measurement is complicated by the unknown amount of deformation caused by heavy wheel loads. Test tracks at the American Oil Company and Washington State University were able to quantify wear rates for both concrete and bituminous surfaces under laboratory conditions which gives proof that highways are damaged by studded tire use.

Montana may be unique to most states in that low traffic volumes just do

not give enough studded tire applications to the surface to cause significant pavement wear at this time. According to research findings, by the time the pavement would be worn sufficiently to cause driving problems, load deformation, skid resistance or weathering factors would more than likely have already given ample cause for the pavement to be resurfaced.

Bridge decks may be worn sufficiently to cause maintenance problems on a few higher traffic volume roads. From wear rates found in the Minnestoa Study, Montana's bridge decks on several miles of its highest traffic volume roads may require repair after thirty to forty years of service. The added repair costs at that time could not be reasonably estimated today.

The research study tried to carefully evaluate studded tire wear rates on Montana Highways in case our conditions were significantly different than those found in Minnesota. The problems of obtaining precise measurements under various weather conditions that affect instruments, electrical battery power, and human accuracy were found to cause errors that were equal or greater in magnitude than the quantity being measured. It was found that even with these errors, Montana wear rates were no greater than that found in the Minnesota study and these will not cause expensive damage to our highways under present traffic and usage conditions.

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